Tribes of doubtful Afghán descent.

I. Sayad.	1	Gangalzai.
	2	Bagarzai.
	3	Ajabzai.
	4	Sha'dizai.
	5	Brahamzai.
	6	Haidarzai.
	7	Ya'singzai.
	8	Urumzai.
II. Karbela.		

(To be continued).

On the Súryaprajñapti.—*By* Dr. G. Thibaut, *Principal, Benares College.*

Part I.

Until recent times our knowledge of the cosmological and astronomical system of the Jainas was very limited and founded not on an independent investigation of the original Jaina literature, but only on the occasional references made to Jaina doctrines by the orthodox Hindu writers on astronomy. For a long time the short account of the subject given by Colebrooke in his "Observations on the sect of the Jainas" (Asiatic Researches, 1807; Essays, Vol. II), remained the only one, and although accurate as far as it goes, it is very insufficient since it chiefly refers to the one doctrine of the Jainas only, which has at all times struck outsiders as peculiarly strange and absurd, *viz.*, the assertion that there exist two suns, two moons and a double set of constellations. This is indeed the doctrine by which the system of the Jainas could most easily be distinguished from similar old Indian systems, and it is consequently referred to and controverted with preference in the Siddhántas. The best known passage from the latter is the one quoted by Colebrooke from Bháskara's Siddhánta-Siromaṇi. "The naked sectaries and the rest affirm that two suns, two moons and two sets of stars appear alternately; against them I allege this reasoning. How absurd is the notion which you have formed of duplicate suns, moons and stars, when you see the revolution of the polar fish."

This passage of Bháskara's is manifestly founded on a passage found in Brahmagupta's Sphuṭa-Siddhánta where we read in the so-called Dúshaṇádhyáya:

भानि चतुः पञ्चाशत् द्वौ द्वावर्कादयो जिनोक्तं यत्।
ध्रुवमत्स्यावर्त्ता भवति यतोऽक्षा ततस्तदसत्॥

o

"There are fifty-four nakshatras, two risings of the sun; this which has been taught by Jina is untrue, since the revolution of the polar fish takes place within one day."

And a passage to the same effect occurs in the 13th adhyáya of Varáha Mihira's Pañchasiddhántiká.

In 1868 Professor A. Weber, to whom we are indebted for our first acquaintance with so many works of Indian literature, published in the tenth volume of the "Indische Studien" a paper on the Súryaprajñapti, being apparently the most important astronomical book whose authority the Jainas acknowledge, and it then appeared that the doctrine of the existence of two suns, moons, etc. constitutes only one feature of a comprehensive system which on the whole is much less fantastical than might have been expected and which, fantastical or not, shows intimate relations to the astronomical and cosmological views which appear to have prevailed all over India before Greek science began to influence the East. Especially it appeared—as pointed out by Professor Weber—that the doctrine propounded in the Súryaprajñapti shows in many points an unmistakable resemblance with that contained in the Jyotisha-Vedáñga the presumably oldest specimen of Indian astronomical literature, and it thus became manifest that the astronomical books of the Jainas do not only furnish information about the opinions held by a limited religious sect, but may, if rightly interrogated, yield valuable material for the general history of Indian ideas. The writer of the present paper has therefore thought it worth while to submit the Súryaprajñapti to a renewed detailed investigation, whereby we should be enabled rightly to esteem its position in the astronomical literature of India, clearly to conceive the peculiar features distinguishing the astronomical system of the Jainas from other systems, and on the other hand to point out what the Jaina system has in common with other systems, and in what way therefore it may be employed for the elucidation of the latter. Professor Weber's paper gives in the main only a short summary of the contents of each chapter of the Súryaprajñapti, following the order of the chapters as found in the work itself and omitting none of them. This was of course the right plan to adopt in a paper giving the first account of a hitherto unknown book. In the present paper it has on the other hand been preferred to give a connected account of the chief doctrines only which are found in the Súryaprajñapti, to combine hints found in the various parts of the work wherever this appeared necessary for the sake of greater clearness, and again altogether to omit relatively unimportant matter. It must be stated at the outset that this paper—like that of Professor Weber—is based more on Malayagiri's commentary on the Súryaprajñapti than on the text of the latter work itself; which apparently anomalous proceeding finds its explanation in the fact of the Manuscripts

of the Súryaprajñapti, commonly met with, containing the commentary only *in extenso*, while as a rule only the first words of the passages commented on are given. As it, however, appears that the commentary faithfully follows the text, and as on the other hand the latter, devoid of a commentary, would be hardly intelligible, the absence of a complete text of the Súryaprajñapti is less inconvenient that might at first be assumed. At any rate we may obtain at present a sufficiently full and accurate knowledge of the contents of the book; and in works of the class to which it belongs the interest attaching to the form is a comparatively small one. As already stated, the present paper is by no means intended as an exhaustive review of the contents of the Súryaprajñapti; it is rather meant as an introduction to a complete edition of the work itself which, on account of the various old materials it contains, well deserves to be published *in extenso*. And an introduction of this kind could not well be missed, even if we possessed a complete edition or translation of the book, as the reader of the text of the work or of a literal translation of the text would find it by no means an easy task unaided to reconstrue the leading features of the system.

The Súryaprajñapti is written in Jaina-prákṛit, and divided into twenty books called prábhṛitas, some of these again into chapters, called prábhṛita-prábhṛitas. The arrangement of the matter treated of is by no means systematical, and the text, still more the commentary are full of tedious reiterations. Malayagiri, the commentator, has done his work most conscientiously; too conscientiously, the reader afflicted by his extraordinary diffuseness often feels tempted to say. Especially he delights in illustrating the numerical rules given in the text by at least half a dozen examples, where one would have sufficed, dwelling with evident complacency on each step even of the simplest calculation. But his comments are very perspicuous and certainly deserve to be extracted, although not to be reproduced *in extenso*.

Proceeding now to our proposed task, let us dispose at the outset of the distinctive doctrine of the Jainas according to which there are two different suns, two moons and two sets of constellations. When inquiring into the origin of this certainly peculiar notion, we are led to a very simple reason, an impartial consideration of which makes the Jaina system appear much less fantastical and arbitrary than we at first are inclined to think. This reason has already been pointed out by Colebrooke, Asiatic Researches, Vol. IX, p. 321, where he says "They (the Jainas) conceive the setting and rising of stars and planets to be caused by the Mountain Sumeru and suppose three times the period of a planet's appearance to be requisite for it to pass round Sumeru and return to the place where it emerges. Accordingly they allot two suns, as many moons, and an equal number of each planet, star and constellation to Jambudvípa; and imagine that these appear on alter-

nate days south and north of Meru." These words scarcely require anything added to be to them in the way of comment. The Jainas hold (as will be seen in detail further on) the old Indian idea of sun, moon and stars revolving round Mount Meru. To anybody holding this opinion, the question must have suggested itself "In what time is one such complete revolution performed?" The prevailing opinion, represented for instance by the Puráṇas, was that the whole revolution is performed in twenty-four hours, so that the sun describes during the time when it is day in Bharatavarsha the southern half of his circle, and during the time when it is night to the south of Mount Meru, and day in the countries north of it, the northern half. The Jainas, however, took a different view of the matter. To them it seems to have appeared more appropriate that as there are four directions—south, west, north and east—the sun's circle should be divided into four quarters corresponding to the four directions, and that he should bring day in succession to the countries to the south, west, north and east of Meru But then, as it must be supposed that his passing through each of the four quarters occupies the same time, how can it come about that he again appears to rise to the Bharatavarsha after the lapse of a period only sufficient to advance his place by one quarter of the circle? Out of this difficulty the Jainas extricated themselves by simply assuming that the sun rising on a certain morning is not the same sun which had set on the preceding evening, but a second sun similar in every way to the first one. The whole circle is thus described by two suns separated from each other by half the circumference, each of which appears in the Bharatavarsha on alternate days. The same reasoning lead to the assumption of two moons and two sets of stars.

Great as appears to be the difference produced by this hypothesis between the system of the Jainas and the commonly received opinions, it practically is of very small importance and may—as will be done in the following—as a rule be left altogether out of account whenever we have to consider the motions of sun and moon. When for instance the sun having started from Aśviní has passed through the twenty-eight nakshatras, he enters, according to the generally received opinion, again into the same nakshatra Aśviní, according to the Jaina opinion into a second nakshatra called Aśviní too; but as this second nakshatra has the same name, the same extent, and the same relative position as its namesake, as like the latter it is preceded by Revatí and followed by Bharaṇí, and as at the same time when the sun has entered into the second Aśviní, another sun the exact and indistinguishable counterpart of the former one has entered into the former Aśviní, it is clear that we may, when speaking of the motion of the heavenly bodies, save ourselves the trouble of continually referring to two suns, two moons and two sets of nakshatras and, remembering

that there are two of each kind, express ourselves as if there were only one. To proceed.

The astronomic-chronological period on which the system of the Súryaprajñapti is based, is the well-known quinquennial yuga or cycle with which we have long been acquainted from the Jyotisha Vedáñga. The same cycle is described in the Garga Saṃhitá as we see from the extant fragments of the latter work, and we learn from Varáha Mihira's Pañchasiddhántiká that it likewise formed the fundamental doctrine of a Paitámaha Siddhánta which, according to Varáha Mihira's judgment, was one of the more important Siddhántas known at his time. It is alluded to and rejected in a few words by Brahmagupta in the dúshaṇádhyáya of the Sphuṭa Brahma-siddhánta. References to this cycle are met with in the early history of Buddhism. Whether the so-called Vedic literature is acquainted with a cycle of this nature is doubtful.* It will not be necessary to dwell in this place at length on the constitution of the yuga; it will suffice to state that it is based on the assumption of five sidereal revolutions of the sun being exactly equal in duration to sixty-seven periodical revolutions of the moon and to sixty-two synodical months, while one complete revolution of the sun is supposed to be performed in three hundred and sixty-six days. That a cycle of this nature based as it is on an utterly wrong assumption could maintain itself for a considerable time as it manifestly has done is a matter for legitimate wonder, and does not find a parallel in the history of chronological systems among any other civilized nation. At the end of one yuga already the quantity of the error induced by the mistaken estimation of the length of the solar year amounts to nearly $5 \times \frac{3}{4} = 3\frac{3}{4}$ days, the accumulation of which quantity after the lapse of a few yugas could not escape the attention, we should think, of even the most careless observers. The matter would indeed lie altogether differently if a conjecture (or as it stands we might almost say, an assertion) of Colebrooke referring to this point had been verified. He—after having given an account of the manner in which the Jyotisha-Vedánga manages to maintain harmony between civil and lunar time—continues "and thus the cycle of five years consists of 1860 lunar days or 1830 nycthemera, subject to a further correction, for the excess of nearly four days above the true sidereal year: but the exact quantity of this correction and the method of making it, according to this calendar, have not yet been sufficiently investigated to be here stated." The fact is that of this correction which Colebrooke considered so indispensable, that he speaks of it as being actually found in the Vedánga, no

* The question referred to in the text cannot be discussed here. The writer hopes shortly to find an occasion fully to treat it elsewhere.

traces are to be found either in the Vedánga itself or—and this is of great importance as the Vedánga is still partially unexplained—in the Súryaprajñapti which illustrates the constitution of the quinquennial yuga in the most diffuse manner, but has nothing to say about a correction of the kind mentioned.—The subdivisions of the yuga are in the Súryaprajñapti described with great fulness ; what is really essential admits, however, of being stated in a few words. Each solar year is divided into two ayanas of one hundred and eighty-three days each. Each ayana in its turn comprises six solar months, each of which lasts $30\frac{1}{2}$ days. Two of these solar months constitute a solar season ; the reckoning of the seasons starts, however, not from the beginning of the yuga, but the latter is made to mark the middle of a season, so that the rainy season which counts as the first begins a month before the beginning of the yuga. Again the yuga comprises five years of 360 days each, each year in its turn being divided into twelve months of 30 days each ; in the Súryaprajñapti this kind of year—commonly known as the sávana year—is called the *karma-year* or *ritu-year* which latter name would more properly be given to the solar year. The six days by which this year is shorter than the solar year are called atirátras. Again the yuga comprises sixty-two synodical months, the first of whom begins with the moon being full in the first point of Abhijit. Each of these months is divided into a light and a dark half ; each half comprises fifteen tithis or lunar days of equal duration. Sixty-two of these months being equal in duration to sixty-one karma-months of 30 days each, it follows that sixty-two tithis are equal to sixty-one natural days ; in order therefore to maintain harmony between the numbers of the natural days and those of the tithis, a break in the counting of the tithis is made whenever two tithis terminate during one natural day, *i. e.*, according to the Súryaprajñapti on the occurrence of each sixty-second tithi. The details of this process are not stated in the Súryaprajñapti, but there can be no doubt that *mutatis mutandis* it was managed as it has been managed in India ever since. To give an example, the sixtieth natural day, counting from the beginning of the yuga, during which the sixtieth tithi terminated was counted as pañchadaśí (fifteenth tithi), the next following day as pratipad (first day of the new lunar half month) and then the day after that not as dvitíyá, second lunar day, but as tṛitíyá third lunar day, the second lunar day having already terminated together with the preceding sixty-first natural day. These sixty-two lunar months are divided among five lunar years, the first, second and fourth of which comprise twelve lunations each, while the third and fifth count thirteen each. The technical name of years of the latter kind is abhivardhita-saṃvatsara, the increased year. The method according to which the two thirteenth months are intercalated in the yuga is

not described in detail; it is however clear enough how it proceeded. The thirty-first lunation and again the sixty-second one were not counted, but formed together with the month immediately following a kind of double month taking its name from the second constituting member. Thus there is nominally no thirteenth month, and a proper name for the latter is therefore not required.

Again the yuga consists of sixty-seven periodical lunar months, the moon during it returning sixty-seven times to the place from which she had started at the beginning. No attempt is made in the Súryaprajñapti to group these months into years nor are they subdivided into days of equal duration; they are simply said to comprise 27 $\frac{21}{67}$ days each. They are, however, subdivided into two ayanas each, analogously to the division of the solar year into ayanas. This division is indeed legitimate enough as it is based on the alternate progress of the moon towards the north and south, about which details will be given later on. Less comprehensible is on the other hand the division of each periodical month into six lunar seasons, whose names answer to those of the solar seasons beginning with the rainy season; a division of this kind is of course utterly gratuitous and purposeless, and to us interesting only as a specimen of the Indian's excessive tendency to systematize.

If we now proceed to an examination of the account given in the Súryaprajñapti of the revolutions of sun and moon, we find at the outset that it differs from the statements made by Garga and in the Vedánga in one important point. According to the latter authorities (see Jyotisha-Vedánga, v. 6; this Journal for 1877, p. 415; Weber, Nakshatras II, pp. 28, 33), the yuga begins with the winter solstice, at the moment when it is new-moon, sun and moon being in conjunction in the beginning of the nakshatra Dhanishṭhá; according to the Súryaprajñapti the yuga begins with the summer solstice, at the moment when the moon is full in the beginning of Abhijit and the sun consequently stands in Pushya. The coincidence of the winter solstice with new moon marking, according to the Vedánga, the beginning of the yuga may of course actually have taken place at the time when the doctrine of the quinquennial yuga was first established and will have recurred later on from time to time; but it is evident that it could not regularly recur every fifth year. To this fact, however, as well as to the change which in consequence of the precession of the equinoxes gradually took place in the position of the sun at the time of the winter solstice, the eyes of the Hindus seem to have remained shut during a considerable period. Now it is curious to see that in this one point at least the author of the Súryaprajñapti who, on the whole, faithfully adheres to the old system and does not hesitate to take over the quinquennial yuga itself with all its glaring imperfections, considered himself entitled or

obliged to deviate from the received tradition. For once the testimony of the eyes was placed above old authorities. In the first place, the winter solstice had so far receded from the beginning of Dhanishṭhá that the change could not be ignored; in the second place, it must have so happened that at the time of the author of the Súryaprajñapti no new moon took place together with the winter solstice, while—as we may presume—some full moon happened to coincide or nearly to coincide with some summer solstice. Accordingly the beginning of the yuga was changed. Faute de mieux the summer solstice coinciding with full moon was taken as the new starting-point, and the sun's place at the time was removed from the middle of Áśleshá which it had occupied in the old system to a point in Pushya. The moon's place at the time of the summer solstice, being separated from the sun's place by half the circumference, is then at the beginning of Abhijit; the latter point marks at the same time the sun's place at the time of the winter solstice.

The account given in the Súryaprajñapti of the position of the sun at the two solstices enables us to enter into a consideration of the approximate time at which either the work itself or some older work on which it may have been based was composed. The expression "approximate" is used on purpose as the general difficulties besetting an estimation of this kind referring to Indian astronomical works are well known, and as in our case special difficulties arise in addition to them. As will be seen later on, the Súryaprajñapti throughout employs twenty-eight nakshatras of unequal extent, while the Vedánga as well as the bulk of the later astronomical literature make use of twenty-seven nakshatras of equal extent. The relation of these two systems to each other necessitates a short excursus, for the starting-point of which we take a passage in Bháskara's Siddhánta Siromaṇi (Grahagaṇita, Spashṭádhikára, 71-74, p. 93 of Bápu Deva's edition) and a parallel passage from Brahmagupta's Sphuṭa-siddhánta. The former of the two, translated, runs as follows:

"This method of finding the Nakshatras which has thus been taught in a rough manner by the astronomers for the purposes of common life, I shall now teach in an accurate form as it has been proclaimed by the ṛishis for the purpose of processions, marriages, etc. The experts have declared six (nakshatras) to have one portion and a half, *viz.*, Viśákhá, Punarvasu and the (four) nakshatras called dhruva; six to have half a portion, *viz.*, the constellations presided over by the Sarpas, Rudra, Váyu, Yama, Indra, Varuṇa; the remaining fifteen to have one portion each. The portion of one nakshatra is called the mean motion of the moon (during one ahorátra). The minutes of the circle lessened by the portions of all (the 27 mentioned) nakshatras are the portion of Abhijit, lying beyond the nakshatra of the Viśve Devas, etc." These statements are repeated in Bháskara's own

commentary, the Vásaná, where the common names of the nakshatras (Viśákhá, Punarvasu, Rohiṇí, the three Uttaras;—Áśleshá, Árdrá, Svátí, Bharaṇí, Jyeshṭhá, Śatabhishaj) are given and where Puliśa, Vasishṭha, Garga and others are said to be the Ṛishis alluded to in the text. The rough mode of computation referred to in the beginning of the above quotation is the one contained in v. 67 of the same chapter and agrees with the rule given in the Súrya Siddhánta, II, 64. According to it, when we wish to find the place of sun or moon or one of the planets in the circle of the nakshatras, we have to divide the longitude of the heavenly body expressed in minutes by 800; the quotient then shows the number of nakshatras through which the planet has already passed, and the remainder the traversed part of the nakshatra in which it is at the time. This rule therefore bases on the assumption of twenty-seven nakshatras each of which extends over one twenty-seventh part of the circle. Now, according to Bháskara, the Ṛishis taught that whenever greater accuracy is required, the nakshatras have to be considered as being of unequal extent. In the first place only fifteen of them are to be regarded as having the average extent, while six exceed that amount by one half and six others remain below it by one half; and in the second place the twenty-seven nakshatras are no longer to occupy the whole circle, but only that part of it which corresponds to twenty-seven times the mean daily motion of the moon, while the remaining part of the circle is assigned to a twenty-eighth nakshatra Abhijit. Bháskara's statements are manifestly founded on a passage met with in the 14th chapter of the Sphuṭa Brahmasiddhánta which gives the same details regarding the different extent of the nakshatras, and is introduced by the following verse—

पौलिशरोमकवासिष्ठसौरपैतामहेषु यत्प्रोक्तम्।
तन्नक्षत्रानयनं नार्यभटोक्तं तदुद्धरतः॥

"The calculation of the nakshatras, which has been taught in the Pauliśa, Romaka, Vásishṭha, Saura, Paitámaha Siddhántas, is not mentioned by Áryabhaṭa; I therefore proceed to explain it."

And later on—

अध्यर्धादिक्षेत्राणि संहितास्वभिहितानि गर्गाद्यैः।
यस्मात् बह्वनि तस्मान्नार्यभटोक्तं तदानयनम्॥

The explicit statement about number and extent of the nakshatras in the older period of Indian astronomy, which is contained in the two passages quoted from Brahmagupta and Bháskara, is of considerable interest. If the account given by these two writers is correct and there is no reason to doubt of that, it appears in the first place that the mere circumstance of only twenty-seven nakshatras being mentioned in some detached fragment of an astronomical work which we do not possess in its entirety,

would not justify the conclusion of the author of the work having been acquainted with twenty-seven nakshatras only. Nay, even the author of a treatise like the Vedánga who throughout speaks of 27 nakshatras only may have done this simply because he meant his work to be an elementary one, unencumbered by the assumption of 28 nakshatras of unequal extent. In the second place the distinct statement that the old writers on astronomy made use of Abhijit solely when greater accuracy was aimed at, and that they then made its extent to correspond to the excess of a sidereal month above twenty-seven days, certainly seems to point to the conclusion that the introduction of Abhijit into the circle of the nakshatras was an afterthought, consequent on the improved knowledge of the length of the moon's periodical revolution. With regard to the books in which, according to Bháskara and Brahmagupta, the division of the sphere into 28 nakshatras of unequal extent was taught in addition to the simpler division into 27 equal nakshatras, we have to remark that the Súrya-siddhánta known to us contains no such statement; the Saura-siddhánta of Brahmagupta may have been a different work. We are unable to control the statement with regard to the Romaka, Pauliśa, Vásishṭha-Siddhántas. Of Garga, however, we know from quotations several passages bearing on the point in question: in the first place, the passage quoted by Bhaṭṭotpala (in his commentary an Varáha Mihira's Bṛihatsaṃhitá, IV, 7; see Weber, Nakshatras, I, p. 309), which corroborates Bháskara's statement regarding the different extent of the Nakshatras, is, however, silent about Abhijit. As the passage stands, it would lead us to infer that Garga divided the whole circle into twenty-seven parts, the extent of fifteen of which is equal to one, of six to one half and of six to one and a half. The quotation may, however, be incomplete, and at any rate we have Brahmagupta's and Bháskara's word for Abhijit having been acknowledged by Garga too. However this may be, that Garga, as a rule, introduced into his calculations neither Abhijit nor the inequality of the extent of the twenty-seven nakshatras, appears from the places which he assigns to the sun at the two solstices, *viz.*, at the beginning of Dhanishṭhá and the middle of Áśleshá; for if we calculate the place of the summer solstice by starting from the beginning of Dhanishṭhá and making use of the unequal extent of the nakshatras, we obtain as place of the summer solstice not the middle of Áśleshá but rather the end of it or the beginning of Maghá.

To return. The special difficulty by which we are met when attempting to compare the places assigned to the solstices in the Súryaprajñapti with the places which they occupy according to Garga and the Vedánga on one hand and the Siddhántas on the other hand, lies in the circumstance of our not knowing exactly how the two divisions of the sphere—the one into 27 nakshatras of equal extent, the other into 28 of unequal extent—were made

to correspond with each other. If we suppose—and this seems the most likely supposition—that each of the 27 nakshatras was curtailed by the twenty-seventh part of the small portion assigned to Abhijit and that the reckoning started from the beginning of Abhijit, (which according to the system of the Súryaprajñapti is the first of the series, as at the beginning of the yuga it is in conjunction with the moon), we may hazard an hypothesis with regard to the time lying between the Vedánga and the Súryaprajñapti, or rather between the observations of the solstices recorded in the two works. According to the Vedánga the winter solstice takes place in the beginning of Dhanishṭhá, according to the Súryaprajñapti in the beginning of Abhijit (which is the place of the full moon on the day of the summer solstice at the beginning of the yuga, and consequently the place of the sun on the day of the winter solstice); the two places are therefore separated by the whole of Śravaṇa and Abhijit. Having, according to the hypothesis stated above, reduced the extent of Śravaṇa (= 13°·33) by the 27th part of the extent of Abhijit, which extent is equal to about 4°·12, we obtain for Śravaṇa 13°·18; to this we add Abhijit = 4°·12; the sum *viz.*, 17°·3 indicates the extent of the displacement of the solstice during the intervening period. Allowing seventy-two years for 1° of precession, the length of this period would be about 1246 years. If we therefore knew the absolute date of the Vedánga we might state the approximate absolute date of the observation recorded in the Súryaprajñapti, on the supposition always of the manner in which the two divisions of the sphere have been adjusted to each other being the right one. But, as Professor Whitney has shown, it is scarcely possible to form any satisfactory conclusion with regard to the date of the Vedánga, and we therefore abstain from giving a positive opinion about the date of the Súryaprajñapti.

We now proceed to a detailed consideration of the hypothesis by which the author of the Súryaprajñapti tries to account for the appearances presented by the various motions of the heavenly bodies, beginning with the sun.

The three different motions of the sun which he endeavours to explain are firstly, the daily motion in consequence of which the sun seems to approach us from the East, passes through our field of vision and finally disappears in the West; secondly, the annual motion in consequence of which the sun seems to pass in the course of a year through the circle of the nakshatras, proceeding from the West towards the East; and thirdly the motion in declension according to which the sun ascends towards the north during one half of the year and descends towards the south during the other half. As in all systems which consider the daily motion of the sun to be real (not an appearance produced by the revolution of the earth

round its axis), the annual motion of the sun through the circle of the nakshatras is said to be apparent only, and produced by the circumstance of the motion of the sun being somewhat slower than that of the nakshatras, so that he daily lags behind by a certain quantity which accumulated during a whole year amounts to an entire revolution. How the Súryaprajñapti supposes the first and third motions to take place will appear from the following.

It must be remembered at the outset that the general conception of the configuration of the world which we find in the Súryaprajñapti is the same as that known from the Puráṇas. The earth is considered to be an immense circular flat consisting of a number of concentric rings, called dvípas, separated from each other by ring-shaped oceans. In the centre of the earth stands Mount Meru; around it runs the first dvípa—Jambudvípa, the only one which will concern us in the following. It is surrounded by a circular ocean, the water of which is salt (the lavaṇa-samudra). The southern segment of the Jambudvípa is occupied by the Bháratavarsha, the northern segment by the Airávata-varsha; east and west of Mount Meru are the two portions of the Videha-varsha. Sun, moon and stars revolve round Mount Meru, in circles of different height above the Jambudvípa, the same heavenly body, however, always keeping the same height. The detailed features of these motions are now according to the Súryaprajñapti as follows.

The circumstance of the sun seeming during one half of the year to approach daily more and more the north, while during the other half he seems to descend towards the south is explained in the following manner. On the longest day of the year which at the beginning of the cycle coincides with the first day of the lunar month S'rávaṇa, the sun describes round the mountain Meru a circle, the diameter of which is 99,640 yojanas. The distance of the sun from the centre of Meru amounts therefore to 49,820 yojanas. On the next day the sun describes a circle concentric with the first, and having a diameter greater by $5\frac{5}{61}$ yojánas, so that the distance of the sun, from Mount Meru now amounts to $49{,}820 + 2\frac{48}{61}$ yojanas. In the same manner the diameter of the circle described by the sun increases by $5\frac{5}{61}$ on the third day, fourth day, etc., up to the day of the winter solstice, which according to the system is the 183rd day after the summer solstice. On this day the sun describes round Mount Meru a circle, the diameter of which is equal to 100,660 yojanas, so that his distance from Mount Meru amounts to 50,330 yojanas. Beginning from this day the solar circles contract again, by the same quantity daily by which they had expanded during the southern progress of the sun. During the 182 days intervening between the day of the winter solstice and the day of the following summer solstice the sun describes again the same 182 circles in

which he had descended towards the south, only in reverse order, until, on the day of the second summer solstice, he has again reached the innermost circle, from which he had started a year ago. During the second year the same expanding and contracting of the solar circles repeats itself and so on. The fact of the sun seeming to ascend towards the north during one half of the year, while he seems to descend towards the south during the other half is therefore explained by the supposition that he approaches us during the former half, while he recedes from us during the latter half. The system does not assume that he actually ascends or descends; for all the circles described by him are at an equal height above the Jambudvípa; he only appears to us to stand lower at the winter solstice than he does at the summer solstice, because at the former period he has receded from us to the amount of five hundred and fifty yojanas. The exact localities too above which the sun describes his daily circles are defined. The innermost circle, *i. e.*, the circle nearest to Mount Meru, which the sun describes on the longest day, would, when projected upon the earth, be distant 180 yojanas from the outer margin of the Jambudvípa. The second circle approaches nearer to that margin, the third still nearer, and so on, until the circles of the sun are no longer above the Jambudvípa itself but above the salt ocean, the lavaṇoda, which surrounds the Jambudvípa. Finally on the shortest day of the year the sun describes a circle which, in projection, is distant 330 yojanas from the edge of the Jambudvípa. After that he again approaches the Jambudvípa, and on the next summer solstice he has again entered into it to the amount of 180 yojanas. The technical term by which this recurring progress of the sun towards the Jambudvípa and the salt ocean is denoted in the Súryaprajñápti, is उगाहइ or अवगाहति (-ते); the sun is said to merge himself, or to enter to a certain distance into the Jambudvípa or into the salt ocean accordingly as his circles are vertically above the land or the surrounding sea.

In connexion with the sun's motion in circles of different diameter, the Súryaprajñapti treats of the increase and decrease of the length of the day. As in the Jyotisha-Vedánga, the length of the day of the summer solstice is estimated at eighteen muhúrtas, that of the shortest day at twelve muhúrtas. The days between the two solstices are erroneously supposed to decrease or increase by a uniform quantity, which is easily found to be equal to $\frac{6}{183} = \frac{2}{61}$ of a muhúrta.

A number of opinions of other teachers agreeing with the theory stated above in its general features, but differing in the figures, are likewise given by the Súryaprajñapti.

Different opinions regarding the extent of the solar circles are given in I, 8 and, which comes to the same, different opinions about the distance of the two suns from each other in I, 4. According to this chapter there

were six different opinions about the distance of the two suns from each other on the longest day when the sun—or the two suns—describe the innermost and smallest circle. According to some teachers, the distance of the two from each other, or in other words the diameter of the circle they describe amounts to 1,133 yojanas, according to others to 1,134 yojanas; according to others again to 1,135 yojanas. Most probably we have to combine with these statements the statements given in the next chapter (I, 5) regarding the different opinions prevailing on the extent to which the sun "immerges" himself into the Jambudvípa and into the salt ocean. There we read that, according to one opinion the sun moves on the longest day in a circle which projected on the Jambudvípa is distant 1,133 yojanas from the edge of the latter, while on the shortest day he describes a circle above the salt ocean at the distance of 1,133 yojanas from the Jambudvípa. According to the opinions of two other sets of teachers, the number of yojanas in both cases is 1,134 and 1,135. If we combine these measures with the measures of the diameter of the innermost solar circle given above (and the sameness of the figures seems to entitle us to do so, although this is by no means explicitly stated), we get for the diameter of the whole Jambudvípa 1,133 (= diameter of the innermost circle) + 2 × 1,133 (= distance of the innermost circle from the edge of the Jambudvípa on both sides), therefore altogether 3,399 yojanas; or, starting from the numbers 1,134 and 1,135, 3,402 or 3,405 yojanas. These are very moderate dimensions compared with the 100,000 yojanas, which length the author of the Súryaprajñapti himself attributes to the diameter of the Jambudvípa, and we shall not be mistaken in ascribing to opinions of this nature a considerably greater antiquity than to those represented by the Súryaprajñapti. Besides, there is another circumstance in favour of such a view. The Súryaprajñapti throughout makes use of the relation $\sqrt{10} : 1$ for calculating the circumference of a circle. Thus for instance the diameter of the Jambudvípa being 100,000 (yojanas), its circumference is said to amount to 316,227 yojanas 3 gavy. 128 dhan. $13\frac{1}{2}$ añg. But those teachers who stated the diameter of the innermost solar circle to amount to 1,133 or 1,134 or 1,135 yojanas stated at the same time that its circumference amounts to 3,399 or 3,402 or 3,405 yojanas, *i. e.*, they made use of the relation 3 : 1 for calculating the circumference of a circle from its diameter. The adoption of this very rough approximate value seems to point back to a comparatively ancient time.*

* It seems that all Jaina books take $1 : \sqrt{10}$ as expressing the relation of the diameter to the circumference. See for instance Bhagavatí Sútra II, 1. 45 (Weber, p. 264), where, however, some confusion seems to have crept into the figures. The old and simple relation 1 : 3 is found for instance in the Bhúmiparvan contained in the Bhíshmaparvan of the Mahábhárata. There the circumferences of the planets are

Three more opinions concerning the distance of the two suns from each other on the longest day are quoted. According to the first, one whole dvípa with the addition of the surrounding ocean intervenes between the two; according to the second two dvípas and two oceans; according to the third three dvípas and three oceans. The distance in yojanas is not given. Two more opinions concerning the extent to which the sun enters into the Jambudvípa are stated; according to some the sun enters on the longest day into half the Jambudvípa and on the shortest day into half the salt ocean; the distances in yojanas are not mentioned. And according to others the sun enters neither into the Jambudvípa nor into the salt ocean, but moves in the interval (apántarála) of the two; how we have to imagine this interval does not appear.

The eighth chapter of the first book contains a long exposition of the dimensions of the circles described by the sun. Four different dimensions are stated. Instead of simply giving the length of the diameter, the length and breadth (áyáma and vishkambha) are given; these two are of course equal in a circle. Then the circumference of the circle is given, according to the ratio $\sqrt{10} : 1$, and finally the "váhalya," the thickness of the circle, *i. e.*, the diameter of the space filled by the mass of the sun or more simply the diameter of the sun himself. This amounts according to the Súryaprajñapti to $\frac{48}{61}$ of a yojana. The diameter and the circumference of the circles are of course continually changing, the circle described on the longest day having the smallest dimensions and that described on the shortest day having the greatest. The dimensions of the small circle and the amount of the daily increase have been mentioned above; it is therefore not necessary to follow the Commentator into the very tedious calculation of the dimension of each daily circle. The opinions of three other teachers on the dimensions of the circles, according to which the diameter amounts to 1,133 yojanas etc., have already been mentioned; the thickness of the circle, *i. e.*, the diameter of the sun is held by them to amount to one yojana.

We turn now to the statements regarding the velocity with which the sun moves in his different circles, and among these at first to those made by the Súryaprajñapti itself. The calculation is a very simple one. Each daily circle being described by two suns, each of which travels through half of it in thirty muhúrtas, the whole circle is described by one sun in sixty muhúrtas, and consequently we have, in order to find the velocity of the sun, to divide the periphery of the daily circle by sixty; the quotient is the number of yojanas travelled through by the sun in one muhúrta. Thus the sun, when travelling in the smallest innermost circle, the circumference

stated in numbers which are the threefold of the numbers expressing the diameters: चन्द्रमास्तु सहस्राणि राजनेकादश स्मृतः। विष्कम्भेन कुरुश्रेष्ठ त्रयस्त्रिंशत्तु मण्डलम् etc.

of which is 315,089 yojanas long, passes in one muhúrta through 5,251 $\frac{29}{60}$ yojanas. On the following day both suns travel in the second circle which is somewhat larger than the first one, and consequently the suns having to describe a larger space in the same time, *i. e.*, during the duration of a nycthemeron travel somewhat faster, pass in one muhúrta through 5,251 $\frac{47}{67}$ yojanas. Thus day after day the speed of the two suns is increasing in accordance with the continually increasing extent of the diurnal circles, until on the day of the winter solstice both suns travelling in the outmost circle pass through 5,305 $\frac{15}{60}$ yojanas in one muhúrta. Beginning from this day their speed diminishes as they are again approachiug the innermost circle, until on the day of the next summer solstice their rate of speed is again at its minimum. In connexion with this discussion of the swiftness of the sun, the Súryaprajñapti treats of the question of the distance from which the light of the sun becomes visible to the inhabitants of the Bharata-varsha. By this distance we have, however, to understand not the distance of the sun from the Bharata-varsha in a straight line, but rather that part of the sun's daily circle which lies between the point of the sun's rising and the meridian. It is well known, says the Commentator, that the sun becomes visible to the eye of man at a distance equal to half of the extent (kshetra) over which he travels during the whole day, *i. e.*, at the time of his rising, his distance from us (=from our meridian, although this is not expressly stated in the Súryaprajñapti) is half of the arc which he describes during the whole day. The length of this arc has to be measured simply by the time which the sun takes to travel through it. Thus, for instance, on the longest day the sun is visible to the inhabitants of the Bharata-varsha during eighteen muhúrtas out of thirty; from the moment of his rising he will therefore take nine muhúrtas to come up to the point straight in front of us (to the meridian). Now we have seen before that on the longest day the sun travels over 5,251 $\frac{29}{60}$ yojanas in one muhúrta; consequently he travels in nine muhúrtas over 47,263 $\frac{21}{60}$ yojanas. This therefore is the distance—expressed as an arc of the diurnal circle—at which he becomes visible to the eye of man. On the shortest day on the other hand the sun is visible for twelve muhúrtas only; we have therefore to multiply the amount of his motion in one muhúrta by six in order to find the distance at which he first appears to the eye of man on that day.

Regarding the swiftness of the sun four other opinions are recorded by the author of the Súryaprajñapti. According to some teachers, the sun travels in one muhúrta over six thousand yojanas, and as far as it appears this rate of motion is the same in whatever circle the sun is moving. How these teachers accounted for the fact of the sun taking the same time to travel through a large circle as through a small one is not explained. The

amount of space illuminated on each day (the tápakshetra), expressed as arc of the diurnal circle of the sun, they calculated in the same manner as the author of the Súryaprajñapti, *viz.*, by multiplying the amount of motion in one muhúrta by the number of the muhúrtas of the day. Thus the tápakshetra on the longest day would amount to 108,000 yojanas, that on the shortest day to 72,000 yojanas. According to the opinions of two other schools, the motion of the sun in one muhúrta amounts to 5,000 yojanas or 4,000 yojanas. Here too nothing is said about any variation in the sun's speed at different times of the year. The tápakshetra is calculated in the manner stated above. The last opinion mentioned is that of some teachers who held the rate of speed of the sun to be different during different periods of the day. According to them, the sun passes over six thousand yojanas in the muhúrta after his rising and in the muhúrta preceding his setting, over four thousand yojanas during the muhúrta in the middle of the day and over five thousand yojanas in all other muhúrtas.

The various opinions prevailing with regard to the rising and setting of the sun are detailed in the first chapter of the second book. The opinion of the author clearly appears from what has already been stated. There is no real sunrise or sunset; the sun or rather the two suns revolving round Mount Meru appear to rise to the inhabitants of some particular place at the moment when they enter their field of vision, and they appear to set when they leave it. In reality they always move above the Jambudvípa at the same height, estimated by the Súryaprajñapti to amount to eight hundred yojanas. At the beginning of the yuga at sunrise on the first of Srávaṇa the Bhárata sun becomes visible to the Bhárata-varsha having reached the south-east point of his diurnal circle; diametrically opposite to it, *viz.*, in the north-west point of the same circle the Airávata sun appears to rise to the inhabitants of the tracts north of Mount Meru. During the course of this day the Bhárata sun therefore illuminates the countries to the south; the Airávata sun those to the north of Meru. At the time of sunset the Bhárata sun having passed through the southern segment of his circle disappears from the view of the people south of Meru and enters the view of those west of Meru; these latter therefore have their day while it is night in Bhárata-varsha. At the same time the Airávata sun appears to have set to the people north of Meru and to have risen to those east of Meru. On the second day the Bhárata sun rises to the countries north of Meru and the Airávata sun to the Bhárata-varsha. On the third morning the Bhárata sun has completed a full circle and therefore again rises to the Bhárata-varsha while the Airávata sun again rises to the regions north of Meru. And so on *ad infinitum*. We may recall here a parallel passage from the Vishṇupuráṇa (II, 8), tending to illustrate how sunrise and sunset were conceived to take place on the hypothesis of the sun (the Puráṇas

know of one sun only) moving round Meru. "The sun is stationed at all times in the middle of the day (*i. e.*, it is always midday at that place above which the sun is) and over against midnight in all dvípas. In the same manner rising and setting are at all times opposite to each other in all the cardinal and intermediate points. When the sun becomes visible to any people, to them he is said to rise, and wherever he disappears from the view there his setting is said to take place. Of the sun which is always (above the earth) there is neither setting nor rising; his appearance and disappearance are called his setting and rising."*

The Súryaprajñapti adds an interesting account of other views regarding the sideway-motion (tiryag-gati) of the sun. According to some the sun is not a divinity, but only a mass of rays which in the morning form themselves in the East into a globular shape, pass sideways along this visible world, and in the evening dissolve again in the West. This process repeats itself daily. According to others the sun is the well-known divinity; but each morning he is born anew according to his nature in the ether in the East (svabhávád ákáśa utpadyate), passes along this world and dissolves (vidhvaṃsate) at evening in the ether in the West. According to others the sun is the mighty everlasting god known from the Puráṇas; in the morning he rises in the East, passes over this world, and at evening sets in the West; from thence he returns below to the East, illuminating the parts below. This—the commentator says—is the opinion of those who hold the earth to be a globe; it finds great favour at present among the tírthántaríyas and is thoroughly to be studied in their Puráṇas. This opinion has three sub-divisions. Some say the sun returning at daybreak from the parts below rises in the ether (ákáśe) and sets in the ether; others say he rises or originates (uttishṭhati utpadyate) in the morning on the summit of the mountain of rising (udaya-bhúdhara-śirasi) and perishes (? vidhvaṃsate) in the evening on the summit of the mountain of setting (astamaya-bhúdhara-śirasi); this repeats itself daily. (But, if he "utpadyate" and "vidhvaṃsate," how can he pass under the earth during the night?). Others say he rises in the morning on the mountain of rising and enters in the evening into the mountain of setting, illuminates during the night the subterraneous world and rises again from the mountain of rising. Others say, he rises, that is, originates from the eastern ocean in the morning, pe-

* Mr. Fitz-Edward Hall (Wilson's Vishṇu Puráṇa, Vol. II, p. 242) directs our attention to the "heliocentricism" taught in this passage. But clearly there is no trace of heliocentricism to be found in it. He apparently is misled by the words अर्कस्य सर्वतः सतः which he translates "of the sun which is always in one and the same place." But this translation is quite untenable, since the Vishṇu Puráṇa most unambiguously teaches the sun's revolution round Mount Meru.

rishes at evening in the western ocean (same objection as above); others again, he rises from the eastern ocean, enters at evening into the western ocean, passes during the night through the subterraneous world, rises again from the eastern ocean. The last opinion mentioned is not very clear and an account of it is therefore not given in this place.

The third and fourth books contain particulars about the tápakshetra, *i. e.*, that part of the Jambudvípa which on each day is illuminated by the sun or rather by the two suns. The shape of this tápakshetra the Súryaprajñapti compares to that of a kalambuká-flower turned upwards, a comparison which has to be understood in the following manner. Each of the two suns illuminates a sector of the large circle formed by the Jambudvípa. These sectors are, however, not complete, but a piece is cut off from each by Mount Meru which standing in the middle of the circle repels by its own superior radiancy the rays proceeding from the two suns and therefore is not included in the tápakshetra. The interior border of the sectors is thus formed by a part of the circumference of Mount Meru, their outward border by a part of the circumference of the Jambudvípa. Between these two sectors of light there lie two sectors of shade (andhakára); whatever part of the Jambudvípa is covered by the two former enjoys day at the time while it is night in the regions covered by the dark sectors. As the two suns revolve these four sectors revolve with them, sweeping over the whole extent of the Jambudvípa and producing alternate day and night in all its parts. The relative magnitudes of the tápakshetra during the different parts of the year is estimated in accordance with the statements about the relative length of night and day. On the longest day the two suns, moving in the innermost circle, together illuminate three-fifths of the Jambudvípa, each of them three-tenths; on the shortest day they illuminate two-tenths each, together two-fifths. On the day after the summer solstice when the suns have entered into the second circle, and are moving at a greater distance from the centre, the extent of the tápakshetra decreases accordingly, so that it then equals $\frac{3}{5} - \frac{1}{5 \times 183} = \frac{3}{5} - \frac{1}{915}$ of the whole Jambudvípa only; the same decrease repeats itself daily up to the day of the winter solstice when the extent of the illuminated portion of the Jambudvípa has reached the minimum stated above. From that period it again begins to increase by the same portion daily. From this the absolute dimensions of the tápakshetra or, to express it more conveniently, of one of the two sectors composing the tápakshetra are easily derived. The two straight lines by which it is limited are equal in length to the radius of the Jambudvípa less the radius of Mount Meru (50,000 — 5,000 = 45,000 yojanas). To this we find in one passage of the Súryaprajñapti added the sixth part of the breadth of the salt ocean surrounding the Jam-

budvípa, up to the end of which the light of the sun seems to reach, on the longest day at least; this gives altogether 78,333⅓ yojánas ($= 45{,}000 + \frac{200{,}000}{6}$). In the statements regarding the measure of the two arcs limiting the sector, no reference is made to the salt ocean. We find these measures for the longest day by dividing the circumference of Mount Meru as well as that of the Jambudvípa by ten; three of these ten parts of the first kind give the interior arc of the truncated sector, three of the second kind the exterior arc. On the shortest day we have to take two-tenths instead of three, and there is no difficulty in finding the corresponding increase or decrease on all days between the summer and winter solstice. In the same manner the dimensions of the andhakára, the dark portion of the Jambudvípa, are readily ascertained. Finally some statements are made about the distances to which the light of the two suns reaches above, below and towards both sides. It is said to reach to a thousand yojanas above (above the chariot of the sun, svavimánád úrdhvam). Further it is said to reach down to the depth of 1,800 yojanas, for which the following explanation is given. The sun is at the height of 800 yojanas above the earth, and below the surface of the earth at the depth of 1 000 yojanas are the subterraneous regions (adholaukikagrámáḥ), down to which the sun's rays are penetrating. No further details about these subterraneous dwellings are given. Towards both sides, the east and the west, the light of the sun is said to extend to the distance of 47,263 $\frac{21}{60}$ yojanas.

For the sake of completeness, the various other opinions with regard to the subjects treated in the last paragraphs are added. Some say that the sun and moon illuminate one dvípa and one ocean; while according to others the numbers of dvípas and oceans illuminated are 3, 3½, 7, 10, 12, 42, 72, 142, 172, 1042, 1072. No details are given. One chapter contains the enumeration of a number of very fanciful opinions about the form of the tápakshetra, which it would, however, be purposeless to extract in this place.

On the assumption that the sun describes every day a circle which is at the distance of 2 $\frac{48}{61}$ yojanas from the circle described on the preceding day, the question naturally suggested itself, how the sun passes over from one circle into the next one. This question is treated in I, 6, and II, 2 where two different opinions are expounded which, although the account given of them is not altogether clear, appear to be of the following nature. According to some the sun enters from one circle into the other, "bhedaghátena" which (bheda being explained to signify apántarála) seems to mean that the sun passes from one circle into the next one by moving over the distance separating the two all at once. Thus the sun would really move in perfect circles and the motion across from one circle into the

other would be a momentary one only. The other opinion, and to this the Súryaprajñapti seems to adhere, is that the sun does not in reality move in separate perfect circles, but rather in an uninterrupted spiral line. As the Súryaprajñapti expresses it, the sun begins from the moment he has entered the first circle to move "śanaiḥ śanaiḥ" across towards the second circle, and as soon as he has reached the second circle, he begins to move towards the third circle, etc. The term "karṇa" which occurs in this description of the sun's motion seems to denote the spiral line which passing across the whole room between the two circles connects the two; a line which might properly enough be called "karṇa," *i. e.*, diagonal. On this hypothesis then we should have to remember that the sun is only for convenience sake said to describe a separate circle on each day, and that in reality he is supposed to describe a continuous spiral line.

After having thus given a succinct account of the Súryaprajñapti's theory concerning the motion of the sun, we now proceed to consider the statements referring to the motion of the moon.

(To be continued.)

Memorandum on Clay Discs called "Spindle Whorls" and votive Seals found at Sankisà, Behar, and other Buddhist ruins in the North Western Provinces of India.—By H. Rivett-Carnac, Esq., C. S., C. I. E., F. S. A. (With three Plates.)

Last year I submitted for the inspection of the Asiatic Society specimens of stone and clay discs, similar to what are called "spindle whorls" by the Antiquaries of Europe, found by me at the Buddhist ruins of Sankisa, Behar, &c. in the Fatehgarh District, N. W. Provinces of India. Certain clay seals stamped with the Buddhist formula found in the same localities were also exhibited. The resemblance between these "spindle whorls" and those described and figured by Dr. Schliemann in his work "Troy and its Remains" was briefly noticed by me at the time. Since then I have obtained some more specimens of these discs and seals, and I think it well that they should be submitted for the inspection of the Asiatic Society, and that the attention of its Members and of other Antiquaries should be directed to the resemblance to be traced between these remains and those found in the ruins of Hissarlik and in many parts of Europe.

First as regards so called "spindle whorls." When we were encamped at Kanouj, Sankisa and Behar Khas in the Fategarh district, the village urchins were encouraged to bring to us everything in the shape of "Antiquities" that could be grubbed out from these extensive ruins and from neighbouring mounds. These sites, as is well known, present many features